

Decentralized Climate Action in India: The Role of Community-Based Climate Solutions in National Climate Governance with special reference to Solar Energy and Electric Mobility

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Abstract

Climate change presents intensifying environmental, economic, and social challenges, particularly for developing countries such as India, where climate vulnerability intersects with pressing developmental priorities including energy access, poverty alleviation, and sustainable urbanization. While global frameworks such as the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement establish mitigation and adaptation targets, their effectiveness depends significantly on decentralized and community-driven implementation. In this context, community-based climate solutions (CBCS) have emerged as an important bridge between national policy commitments and localized climate action. This paper examines India's renewable energy transition and electric mobility initiatives as examples of decentralized climate governance. Renewable energy programmes implemented by the Ministry of New and Renewable Energy, especially rooftop solar expansion and the PM-KUSUM scheme, promote distributed power generation, solar irrigation, and farmer-centric energy systems. These interventions contribute not only to carbon emission reduction but also to rural income diversification, agricultural resilience, and enhanced energy security. By encouraging local ownership and participatory models, such programmes integrate climate mitigation with inclusive development objectives. Complementing these initiatives, electric mobility policies advanced by the Ministry of Heavy Industries, including the PM E-Drive scheme, support the adoption of electric two-wheelers, three-wheelers, and public transport systems. These measures reduce urban air pollution, lower fossil fuel dependence, and create green employment opportunities within emerging clean energy value chains. The diffusion of electric mobility further demonstrates how local entrepreneurship, cooperatives, and community participation can accelerate low-carbon transitions. By situating these initiatives within a community-based governance framework, the

study argues that decentralized renewable energy systems and electric mobility expansion reinforce climate mitigation and adaptation while promoting socio-economic empowerment. The analysis concludes that India's evolving climate strategy reflects a gradual shift toward participatory and multi-level governance models. Strengthening institutional coordination, expanding climate finance access, and enhancing local capacity-building remain essential to sustaining and scaling community-based climate action in alignment with global climate commitments.

Keywords: Climate Change; Community-Based Climate Solutions; Renewable Energy; Electric Vehicles; PM E-Drive Scheme; PM-KUSUM; Decentralized Energy Systems; Sustainable Development; Climate Governance; Grassroots Participation; India; Low-Carbon Transition, Mitigation, Adaptation Strategies.

1. Introduction

Climate change has emerged as one of the most pressing global challenges of the 21st century, affecting ecosystems, economies, and human livelihoods. Rising temperatures, erratic monsoons, extreme weather events, and resource stress have significant implications for developing economies like India. International climate governance mechanisms such as the United Nations Framework Convention on Climate Change and the Paris Agreement emphasize emission reduction targets and adaptation strategies. However, translating these commitments into effective action requires localized engagement and community participation.

India's climate response reflects a dual objective: achieving sustainable development while reducing carbon intensity. A notable feature of India's strategy is the growing emphasis on community-based climate solutions that integrate mitigation with socio-economic development. Renewable energy expansion plays a central role in this transition. Under the leadership of the Ministry of New and Renewable Energy, India has accelerated solar and wind capacity additions. Programs such as rooftop solar installations and the PM-KUSUM scheme empower farmers to adopt solar irrigation pumps, reducing reliance on diesel and subsidized electricity while promoting decentralized energy production. Solar cooperatives and village-level microgrids further demonstrate how renewable energy can operate as a community-managed climate solution.

In addition to renewable energy, electric mobility has emerged as a critical component of India's low-carbon transition. The PM E-Drive scheme introduced by the Ministry of Heavy Industries incentivizes electric two-wheelers, three-wheelers, and buses, encouraging sustainable urban transport. Community-level adoption of electric vehicles, particularly among small entrepreneurs and public transport operators, reduces air pollution and fossil fuel dependency.

These initiatives signify a shift from centralized, policy-driven climate interventions to participatory governance models that involve local institutions, self-help groups, cooperatives, and urban communities. By examining renewable energy and electric mobility within the framework of community-based climate solutions, this study explores how grassroots participation strengthens India's climate governance architecture while advancing inclusive and sustainable development.

2. Literature Review

Md Rumi Shammin, A. K. Enamul Haque & Islam M. Faisal (2021): A Framework for Climate Resilient Community-Based Adaptation, this work develops an integrative conceptual framework for community-based climate adaptation, emphasizing resilience principles, locally relevant solutions, and resource-efficient models. It highlights how participatory approaches align with sustainable development goals and enhance climate resilience in vulnerable communities.

Subhashree Nath (2024): Mobilizing Transformative Community-Based Climate Change Adaptation: Nath argues for a transformative approach to community-based adaptation that goes beyond basic projects to address structural vulnerabilities, power relations, and socio-cultural barriers. The paper identifies key leverage points for community empowerment and inclusive decision-making.

Aneel Salman & Muhammad Iftikhar ul Husnain (2018) Community-Based Climate Change Adaptation: This book situates CBA within broader climate governance debates, outlining theoretical foundations and linking community roles with policy needs in South Asia. It emphasizes that community participation enhances contextual relevance of adaptation strategies.

Community Based Adaptation to Climate Change through Coastal Afforestation Project (CBACC-CF), Bangladesh (UNFCCC) highlighted in UNFCCC database project demonstrates community-based coastal afforestation with mangrove plantations that protect vulnerable coastal areas, generate carbon sequestration benefits, and enhance socio-economic inclusion of marginalized

groups.

Arun Agrawal (2008) *The Role of Local Institutions in Adaptation to Climate Change*: Agrawal argues that local institutions significantly influence adaptation outcomes. He emphasizes that decentralization enhances adaptive capacity when communities have decision-making authority over natural resources. However, institutional linkages between local and higher governance levels are essential for effectiveness.

Fikret Berkes (2007): *Understanding Uncertainty and Reducing Vulnerability: Lessons from Resilience Thinking* Berkes connects resilience theory with community-based resource management. He explains that adaptive governance, learning systems, and social capital strengthen community resilience to climate variability.

Hannah Reid et al. (2009) *Community-Based Adaptation to Climate Change: An Overview*. Reid and colleagues highlight participatory approaches and indigenous knowledge in vulnerable regions. The study stresses that adaptation strategies are more effective when rooted in local socio-cultural contexts.

N.C. Saxena (1997) *The Saga of Participatory Forest Management in India*. Saxena analyzes India's Joint Forest Management (JFM) program, noting improvements in forest regeneration and community participation but identifying bureaucratic dominance as a limitation.

Nandini Sundar (2000) *Unpacking the "Joint" in Joint Forest Management*: Sundar critically evaluates decentralization in forest governance, arguing that while JFM promotes community engagement, power asymmetries between the state and communities restrict genuine autonomy.

3. Methodology

Research Design

This study adopts a qualitative research design based on secondary data analysis to examine community-based climate solutions in India, with particular emphasis on renewable energy initiatives and electric mobility policies. The research aims to analyze how decentralized interventions contribute to climate mitigation, adaptation, and sustainable development within the Indian governance framework.

Secondary Data Collection

The study is based entirely on secondary data collected from credible and authoritative sources.

Secondary data refers to information that has already been published, documented, or compiled by institutions, researchers, and government agencies.

Sources of Data

Government Reports and Policy Documents:

- Publications of the Ministry of New and Renewable Energy
- Reports and scheme guidelines from the Ministry of Heavy Industries
- Official documents related to the PM-KUSUM and PM E-Drive Scheme
- India's Nationally Determined Contributions (NDCs) under the United Nations Framework Convention on Climate Change

International Reports

- Climate assessment reports published under the Paris Agreement framework
- Reports from multilateral institutions such as the World and UN agencies

Academic Literature

- Peer-reviewed journal articles
- Books and edited volumes on climate governance, renewable energy transitions, and community participation
- Research papers from academic databases such as JSTOR, Google Scholar, and ScienceDirect

Statistical Data

- Renewable energy capacity statistics
- EV adoption data
- Government energy and emissions data

4. Method of Analysis

The collected data were analyzed using descriptive and analytical methods. Policy documents were reviewed to identify objectives, implementation strategies, and community-level impacts. Comparative analysis was conducted to assess how renewable energy and electric mobility initiatives align with community-based climate governance principles.

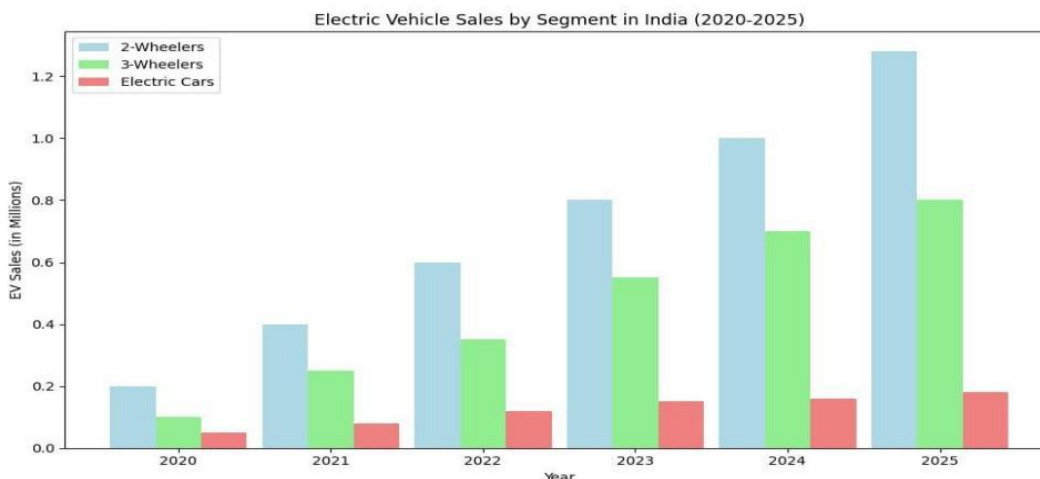
Content analysis was used to interpret themes such as decentralization, grassroots participation, sustainable livelihoods, and emission reduction. The study synthesizes findings from multiple sources to construct a coherent understanding of India's climate action at the community level.

Limitations

Since the study relies exclusively on secondary data, it does not include primary fieldwork or direct stakeholder interviews. The findings are therefore dependent on the accuracy and scope of existing published sources.

5. Success of EV Adaptation and Renewable Energy initiatives In India.

India's electric vehicle (EV) transition represents a significant structural shift in its transport and industrial policy landscape. Although early efforts began under the National Electric Mobility Mission Plan (2013), substantive progress emerged after the launch of the FAME India Scheme, followed by the expanded FAME India Scheme, which allocated ₹10,000 crore to accelerate EV adoption through demand incentives and charging infrastructure development. These interventions transformed India from an early-adoption market (~50,000 EV sales in 2016) into one of the fastest-growing EV markets globally, with annual sales crossing approximately 2.0–2.3 million units by 2024–25. EV penetration in total new vehicle sales increased from nearly 0.7% in 2019–20 to approximately 7.5–8% by 2025, reflecting an average annual growth rate of nearly 60% over the past six years. Segmental analysis indicates that electric two-wheelers dominate the market, accounting for nearly 55–60% of total EV sales (~1.28 million units in 2025), followed by electric three-wheelers (~30–35%; ~0.8 million units). Passenger electric cars constitute only 7–8% of total EV sales (~0.17–0.18 million units), indicating relatively slower diffusion in the private automobile segment. Notably, commercial three-wheelers demonstrate the highest penetration rate (~52% of new sales), suggesting that cost-sensitive and last-mile mobility segments are more responsive to electrification incentives.



From a policy perspective, industrial incentives have complemented demand-side measures. The Production Linked Incentive (PLI) scheme for Advanced Chemistry Cells (₹18,100 crore) and the PLI scheme for automobile and auto components (₹25,900+ crore) aim to localize manufacturing and strengthen domestic value chains. EV expansion also aligns with India's climate commitments under the Paris Agreement, particularly its target to reduce emissions intensity by 45% by 2030 (from 2005 levels) and enhance non-fossil energy capacity. Additionally, EV adoption contributes to reducing crude oil import dependence, which currently stands at nearly 85% of total oil consumption.

Despite these achievements, India's EV ecosystem remains structurally constrained by significant import dependency, particularly in battery technology and critical minerals. Lithium-ion battery cells—constituting 35–40% of EV cost—are almost entirely imported, with China, Japan, and South Korea serving as primary suppliers. Trade analyses indicate that nearly 80–85% of lithium-ion battery imports by value originate from China and Hong Kong (FY2023–24). Critical raw materials such as lithium, cobalt, and nickel are also largely sourced internationally. While India possesses adequate reserves of iron, manganese, aluminum, and partially graphite, it lacks sufficient commercially viable lithium, cobalt, and nickel deposits. Although lithium reserves were identified in Reasi (Jammu & Kashmir) in 2023, commercial extraction remains at a preliminary stage. Moreover, domestic refining and battery-grade processing capacity remain limited, creating a pronounced “processing gap” even where raw materials exist.

Recognizing these vulnerabilities, recent Union Budgets (2024–25 and 2025–26) introduced structural initiatives aimed at mineral security and supply-chain resilience. The proposed Critical Minerals and Rare Earth Mission seek to identify and develop domestic reserves of lithium, cobalt, nickel, and rare earth elements. The concept of “rare earth corridors” emphasizes

States chosen for India's rare earth corridor

The Geological Survey of India identified 482.6 million tonnes of rare-earth ore, mostly concentrated in these states.



Figure 1 Source: PIB



Figure 2 Source: DD NEWS

Complementary measures include customs duty rationalization to promote domestic assembly, scaling of giga-factories under the ACC PLI scheme, and policy support for battery recycling to foster a circular mineral economy. The strategic objective is to gradually reduce lithium-ion cell import dependence—currently near-total—to approximately 20% by FY2027 through domestic capacity expansion.

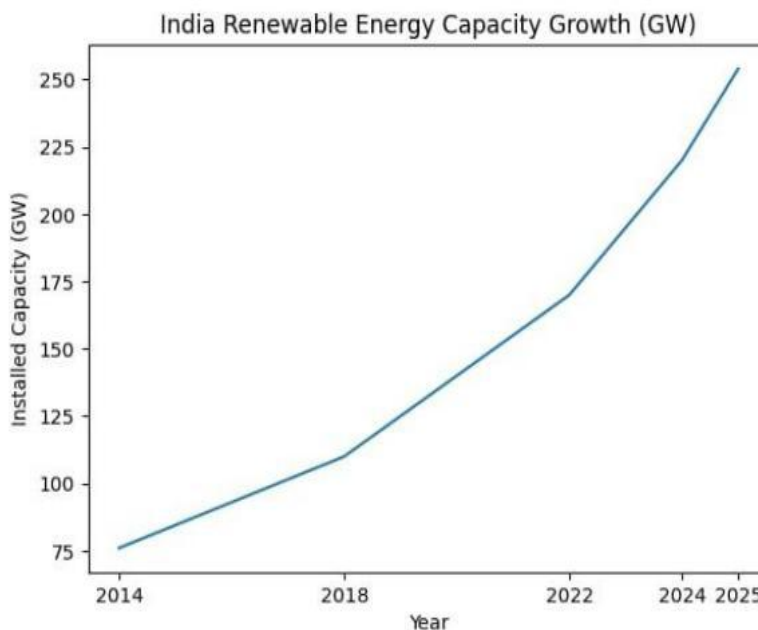
India's EV transition can be characterized as a rapid market success supported by proactive policy intervention and growing environmental consciousness. However, its long-term sustainability depends on addressing mineral security, strengthening domestic battery manufacturing, closing refining gaps, and ensuring technological innovation. The coming decade will determine whether India remains primarily an expanding EV consumer market or evolves into a globally competitive manufacturing hub across the EV and battery value chain.

6. Renewable Energy Success Rate in India

India's renewable energy transition has emerged as a cornerstone of its climate action strategy, transforming energy systems and enabling community-based climate solutions that connect grassroots participation with national and global commitments under the United Nations Framework Convention on Climate Change. Since the launch of the Jawaharlal Nehru National

Solar Mission in 2010, India

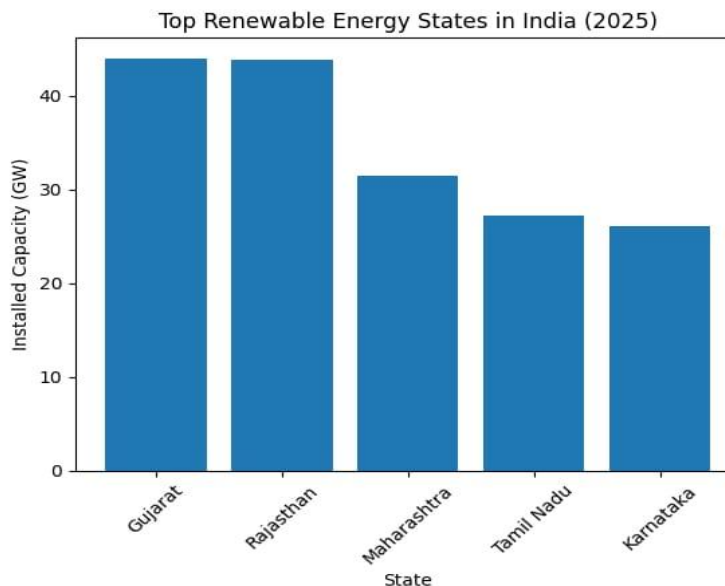
has dramatically expanded its renewable capacity from under 25 GW in 2014 to nearly 200 GW by early 2025, comprising ~74 GW of solar, ~44 GW of wind, ~10 GW of bioenergy, and ~70+ GW of large hydropower. This growth places India among the top five global markets for renewable energy deployment and



demonstrates progress toward its target of 500 GW of non-fossil fuel capacity by 2030

A major driver of solar capacity has been the development of ultra-mega solar parks, large contiguous land-based solar installations designed to achieve economies of scale and attract investment. States such as Rajasthan, Gujarat, and Tamil Nadu host some of the largest solar parks in Asia. For example, the Bhadla Solar Park in Rajasthan — with a capacity exceeding 2.2 GW — has become a flagship project that showcased India's ability to deploy utility-scale clean power at competitive tariffs. Similarly,

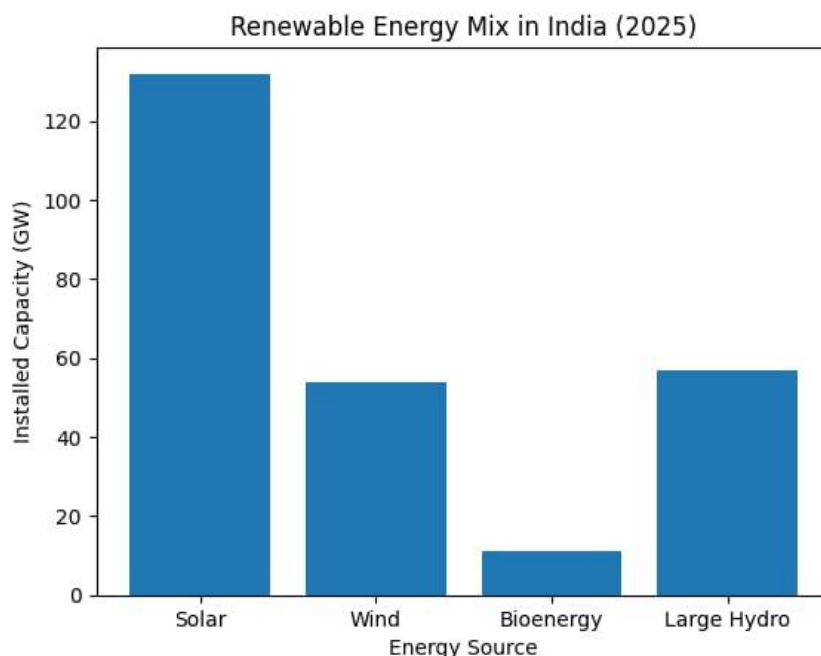
Pavagada Solar Park in Karnataka, spanning over 13,000+ acres with more than 2 GW capacity, has not only generated clean energy but also created local employment opportunities in construction, operations, and maintenance, illustrating how large solar infrastructure can benefit surrounding communities.



At the household and village levels,

decentralized solar initiatives have strengthened local participation and energy autonomy. The PM Surya Ghar Muft Bijli Yojana, launched in 2024, aims to install rooftop solar on 10 million homes, reducing electricity bills for households and decreasing carbon emissions tied to grid demand. Earlier phases of the Grid-Connected Rooftop Solar Programme contributed to nearly 8–9 GW of rooftop installations by 2024, particularly in urban centres and industrial sectors. Such distributed generation empowers citizens to contribute directly to mitigation while reducing transmission losses and increasing grid resilience.

In rural areas, the Pradhan Mantri Kisan Urja Suraksha evam Utthaan Mahabhiyan (PM-KUSUM) has enabled farmers to participate in the renewable economy by solarising agricultural pumps and establishing decentralised solar plants on unused land. Over 150,000 solar pumps and solar power plants under PM-KUSUM have reduced dependence on diesel generators and costly grid electricity, while surplus power fed back to state grids has created supplemental income for farming households. By linking agricultural livelihoods with clean energy, PM-KUSUM integrates climate mitigation with rural economic empowerment.



Bioenergy initiatives such as the SATAT (Sustainable Alternative Towards Affordable Transportation) programme have promoted production of compressed biogas (CBG) from agricultural residues and organic waste, with hundreds of CBG plants operational by 2025. These

facilities reduce methane emissions from waste, support clean cooking solutions, and generate employment in rural processing value chains, reinforcing community-level environmental benefits. Wind energy deployment has also contributed to community benefits. With more than 44 GW of installed wind capacity, states like Tamil Nadu, Gujarat, Karnataka, and Maharashtra support local income generation through land leasing and jobs in turbine installation and maintenance. Hybrid wind-solar parks optimize land use and improve grid integration, reinforcing clean energy gains.

Overall, India's renewable expansion has driven a steady decline in average energy sector carbon intensity — with emission intensity of GDP falling by over 30% since 2005 — and delivered socio-economic benefits at community scales. However, challenges persist: grid integration of variable renewables requires investment in energy storage and transmission upgrades; rooftop solar adoption remains uneven across states due to financing and awareness gaps; and land acquisition for large solar parks sometimes creates local conflicts. Continued emphasis on co-operative ownership models, community financing mechanisms, and inclusion of panchayats and urban local bodies will be crucial to deepen participatory climate action.

In sum, through large solar parks, household solarization, PM-KUSUM for farmers, and decentralised bioenergy, India's renewable energy success embodies a community-anchored climate solution that reduces emissions, enhances rural and urban energy autonomy, and links everyday local action with national climate goals and global climate governance frameworks.

7. Policy Gaps and Recommendations

Despite notable progress, several policy gaps hinder the effective operationalization of Community-Based Climate Solutions in India. One major gap lies in the limited institutionalization of community participation. Although renewable energy and electric mobility policies recognize decentralization, formal mechanisms to embed panchayats, cooperatives, and self-help groups into planning and decision-making processes remain insufficient. Climate programs are often implemented through top-down administrative channels, which can restrict local ownership.

A second gap concerns decentralized climate finance. Access to affordable credit remains a significant barrier for small farmers, women's self-help groups, and local entrepreneurs seeking to adopt solar systems or electric vehicles. While subsidies exist, upfront costs and procedural complexities limit widespread participation. Without inclusive financing mechanisms, CBCS risks

benefiting only relatively better-off groups.

Third, capacity constraints at the local level pose implementation challenges. Many grassroots institutions lack technical expertise in renewable energy maintenance, grid integration, and EV infrastructure management. Insufficient training and technical support reduce the sustainability of community-managed systems. Additionally, uneven charging infrastructure development restricts the expansion of electric mobility in rural and peri-urban areas, undermining equitable participation.

To address these gaps, several policy recommendations emerge.

First, institutional frameworks should formally integrate community-based organizations into renewable energy and EV planning. Decentralized governance structures should be empowered through clear mandates and accountability mechanisms. Second, innovative financing models—such as cooperative credit systems, microfinance integration, and blended public–private partnerships—should be expanded to enhance accessibility. Third, structured capacity-building programs must be implemented to train local stakeholders in technical, financial, and managerial aspects of clean energy systems. Fourth, infrastructure expansion should prioritize underserved regions to ensure inclusive access. Finally, community awareness campaigns emphasizing economic and environmental benefits can encourage behavioral shifts and strengthen grassroots engagement.

By institutionalizing participatory governance, expanding financial inclusion, and strengthening local capacity, India can transform existing climate policies into robust community-driven solutions.

8. Conclusion

Community-Based Climate Solutions represent a transformative approach to climate governance by integrating environmental sustainability with grassroots participation and socio-economic development. India's renewable energy expansion and electric mobility transition illustrate the potential of CBCS to bridge global climate commitments with local implementation. Through policies aligned with frameworks such as the United Nations Framework Convention on Climate Change and the Paris Agreement, India has demonstrated its commitment to reducing carbon intensity while advancing sustainable development goals.

Initiatives led by the Ministry of New and Renewable Energy and the Ministry of Heavy Industries

provide enabling structures for decentralized renewable energy generation and electric mobility adoption. Programs such as the PM-KUSUM and PM E-Drive illustrate how climate mitigation can be localized through farmer participation, cooperative ownership models, and small-scale entrepreneurship. These initiatives generate multiple co-benefits, including income diversification, energy access, pollution reduction, and improved public health outcomes.

However, the long-term success of CBCS depends on strengthening institutional coordination, enhancing decentralized climate finance, and deepening participatory governance mechanisms. Climate action must move beyond policy formulation toward structural empowerment of local institutions. Embedding community leadership within renewable energy and electric mobility planning can enhance accountability, resilience, and inclusivity.

Ultimately, Community-Based Climate Solutions offer a pathway that aligns India's developmental aspirations with its climate responsibilities. By prioritizing grassroots engagement and decentralized governance, India can ensure that its low-carbon transition remains equitable, participatory, and sustainable. CBCS is not merely a supplementary strategy but a foundational framework for achieving resilient climate governance in a diverse and rapidly developing society.

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